

## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
11 March 2004 (11.03.2004)

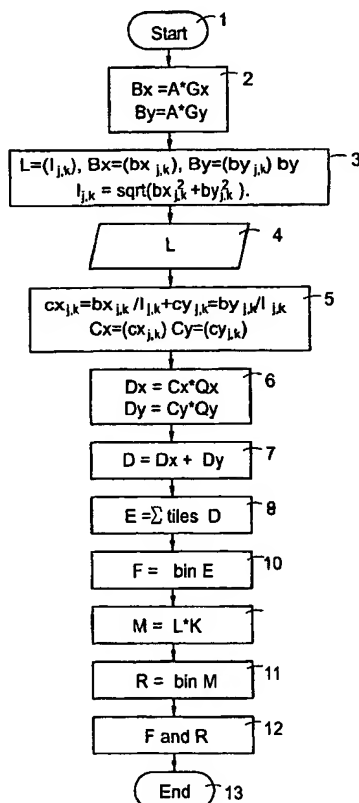
PCT

(10) International Publication Number  
**WO 2004/021262 A2**

- (51) International Patent Classification<sup>7</sup>: **G06K 9/00**
- (21) International Application Number:  
PCT/IB2003/003695
- (22) International Filing Date: 20 August 2003 (20.08.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
102 39 343.5 28 August 2002 (28.08.2002) DE
- (71) Applicant (for DE only): **PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH** [DE/DE]; Stein-  
damm 94, 20099 Hamburg (DE).
- (71) Applicant (for all designated States except DE, US):  
**KONINKLIJKE PHILIPS ELECTRONICS N.V.** [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven  
(NL).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **SCHOLZE, Steffen**  
[DE/DE]; c/o Philips Intellectual Property & Standards  
GmbH, Weissshausstr. 2, 52066 Aachen (DE).
- (74) Agent: **MEYER, Michael**; Philips Intellectual Property &  
Standards GmbH, Weissshausstr. 2, 52066 Aachen (DE).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC,  
SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA,  
UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: METHOD OF PROCESSING A SKIN PRINT IMAGE



(57) Abstract: In a method and an arrangement for processing a skin print image, and particularly a fingerprint image, which image exists as a gray-level image, provision is made for the gray-level image to be convolved in the direction of two axes (x, y) by generalized gradient filters (Gx, Gy), for the generalized gradients (Bx, By) obtained in this way to be normalized, for the normalized, generalized gradients (Cx, Cy) each to be convolved with generalized gradient filters (Qx, Qy), and for the sum (D) of the two results (Dx, Dy) of the convolution of the normalized, generalized gradients (Cx, Cy) to be converted to binary form.



European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

- *without international search report and to be republished upon receipt of that report*

## Method of processing a skin print image

The invention relates to a method of processing a skin print image, and particularly a fingerprint image, which image exists as a gray-level image. The invention further relates to an arrangement for processing a skin print image of this kind.

When an image is made of a print from the skin, and particularly a fingerprint  
5 image is made, what is obtained is data that represents an image in the form of a number, of greater or lesser magnitude, of gray-levels. For a subsequent analysis of the image of the fingerprint aimed at comparing images that have currently been made with stored ones, it is necessary for relevant features to be extracted. These include, for example, the position and number of branchings and endings of ridges (minutiae). It is generally necessary for a binary  
10 image to be produced for processing of this kind, i.e. an image whose brightness values may assume only two states, e.g. black lines on a white background.

It is an object of the present invention to specify a method of processing a skin print image, which image exists in the form of a gray-level image. It is also an object of the present invention to specify an arrangement for processing an image of this kind of a print  
15 from the skin.

This object is achieved in accordance with the invention by a method by which the gray-level image is convolved in the direction of two axes (x, y) by generalized gradient filters (Gx, Gy),

the generalized gradients (Bx, By) obtained in this way are normalized,  
20 the normalized, generalized gradients (Cx, Cy) are each convolved with generalized gradient filters (Qx, Qy) and

the sum (D) of the two results (Dx, Dy) of the convolution of the normalized, generalized gradients (Cx, Cy) is converted to binary form.

The object is also achieved in accordance with the invention by an  
25 arrangement that is provided with means for performing the designated signal-processing steps by the method according to the invention. These means may in particular take the form of means for digital signal processing.

A particular provision that is made in the case of the invention is that the generalized gradient filters (Gx, Gy, Qx, Qy) each constitute the superimposition of a two-

dimensional Gaussian bell curve and a suitably enlarged gradient filter, the size of each of which is adjusted to suit the average density of the furrows in the skin print image.

To enable relevant features of the skin print image to be extracted, it is also necessary for only those parts of the image to be processed that are situated within the region of interest (ROI). To determine these, provision may be made in the method according to the invention for items (L) of length information to be obtained from the generalized gradients (Bx, By), which items (L) of length information are compared with a preset length and, if the preset length is exceeded, the given pixel is designated as belonging to the region of interest.

The method according to the invention can be implemented, in a manner that is particularly efficient in terms of computing time, RAM space required and program memory space required, as a program.

By means of the invention, irregularities in the original image, such as tears, pores, scars, creases, differences in intensity caused by dryness or moisture and/or dirt, can be corrected without any complicated and expensive filtering, such as filtering by Gabor filters and fast Fourier transforms, for example. Also, the method can easily be adapted to different sensors because the number of parameters used is only relatively small. The region of interest is calculated from intermediate results with only a low computing burden.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 shows examples of generalized gradient filters, and

Fig. 2 is a flow chart of an embodiment of a computer program for performing the method according to the invention.

Fig. 1 is a diagrammatic representation of an example of the generalized gradient filters Gx (Fig. 1a) and Gy (Fig. 1b) of 7 x 7 pixel size. In contrast to normal gradient filters (which are, for example, -1, 0, +1 for the x axis), the sign is inverted for one half following a Gaussian bell curve that is symmetrical in rotation. The size of the filter Gx needs to be selected in this case to suit the resolution of the image or the average spacing of

the furrows in the fingerprint. When rotated through  $90^\circ$  in a counterclockwise direction, this gives the generalized gradient filter  $G_y$  in the  $y$  direction

In the flow chart shown in Fig. 2, the program starts at 1 and following this the convolutions  $B_x = A * G_x$  and  $B_y = A * G_y$  are made in step 2. The convolutions produce the values  $B_x$  and  $B_y$  for all the pixels. Then, at 3, the lengths of the generalized gradients  $B_x$  and  $B_y$  are calculated for each of the pixels. The length values are buffered at 4.

In step 5 of the program, the generalized gradients are normalized, likewise pixel by pixel, to give results  $C_x$  and  $C_y$ .

The normalized, generalized gradients  $C_x$  and  $C_y$  are then convolved at 6 with generalized gradient filters  $Q_x$  and  $Q_y$  to give gradients  $D_x$  and  $D_y$ .

At 7, the gradients  $D_x$  and  $D_y$  are added together pixel by pixel.  $D = (d_{k,l})$  is then divided into overlapping, square tiles of equal size, with each  $d_{k,l}$  being situated in exactly the same number  $e$  of tiles. Each tile is converted into binary form individually by taking the mean of all the gray levels occurring in the tile as a threshold value  $b$  for the conversion of this tile into binary form. All  $d_{k,l} \geq b$  are set to 1 and all  $d_{k,l} < b$  are set to 0. The tiles that have been converted into binary form in this way are added together in line with their position, thus giving, at 8, a gray-level image  $B$  having a maximum of  $e+1$  different gray levels. This gray-level image is converted into binary form as a whole in step 9 of the program, using a suitable threshold  $c$ , to give an image  $F$ .

At 10, the stored lengths  $L$  are convolved in two dimensions following a Gaussian bell curve to give a result  $M$ . This latter is assessed at 11 as a globally binarized version  $R$  of  $M$ . At 12, the image  $E$  and the image  $R$  are combined to give a resulting image  $H$ , whereupon the program is terminated at 13.

## CLAIMS:

1. A method of processing a skin print image, and particularly a fingerprint image, which image exists as a gray-level image, characterized in that

the gray-level image is convolved in the direction of two axes (x, y) by generalized gradient filters (Gx, Gy),

5 the generalized gradients (Bx, By) obtained in this way are normalized, the normalized, generalized gradients (Cx, Cy) are each convolved with generalized gradient filters (Qx, Qy) and

the sum (D) of the two results (Dx, Dy) of the convolution of the normalized, generalized gradients (Cx, Cy) is converted to binary form.

10 2. A method as claimed in claim 1, characterized in that the generalized gradient filters (Gx, Gy, Qx, Qy) each constitute the superimposition of a two-dimensional Gaussian bell curve and a suitably enlarged gradient filter, the size of each of which is adjusted to suit the average density of the furrows in the skin print image.

15 3. A method as claimed in either of the foregoing claims, characterized in that, to enable a region of interest of a skin print image to be determined from the generalized gradients (Bx, By), items (L) of length information are obtained that are compared with a preset length and, if the preset length is exceeded, the given pixel is designated as belonging  
20 to the region of interest.

4. An arrangement for processing a skin print image, and particularly a fingerprint image, which image exists as a gray-level image, characterized by means for convolving the gray-level image in the direction of two axes (x, y) by

25 generalized gradient filters (Gx, Gy),

normalizing the generalized gradients (Bx, By) obtained in this way, convolving each of the normalized, generalized gradients (Cx, Cy) with generalized gradient filters (Qx, Qy) and

converting the sum (D) of the two results (Dx, Dy) of the convolution of the normalized, generalized gradients (Cx, Cy) to binary form.

5. An arrangement as claimed in claim 4, characterized in that the generalized  
5 gradient filters (Gx, Gy, Qx, Qy) each constitute the superimposition of a two-dimensional Gaussian bell curve and a suitably enlarged gradient filter, the size of each of which is adjusted to suit the average density of the furrows in the skin print image.
6. An arrangement as claimed in claim 4 or 5, characterized by a means for  
10 obtaining items (L) of length information from the generalized gradients (Bx, By), for comparing these item (L) of length information with a preset length and, if the preset length is exceeded, for designated the given pixel as belonging to the region of interest.

1/2

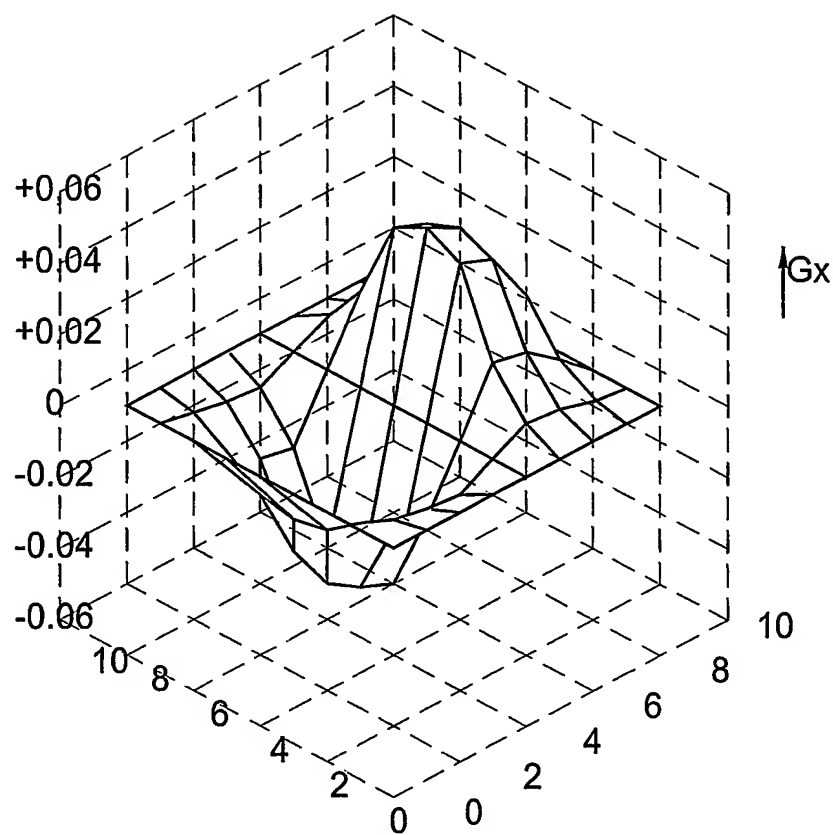


Fig.1a

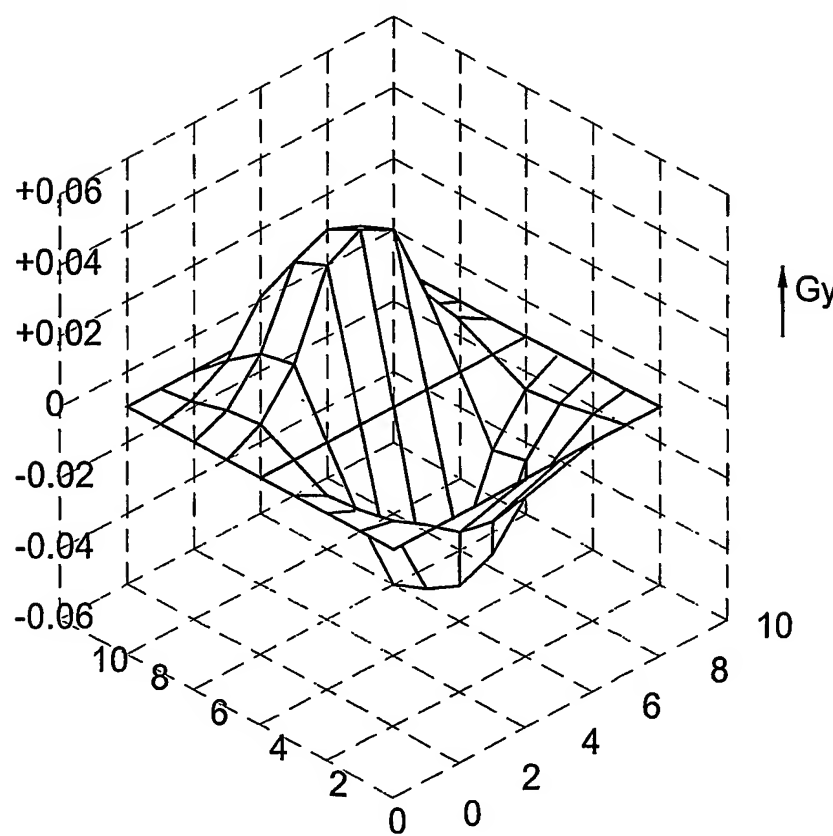


Fig.1b



2/2

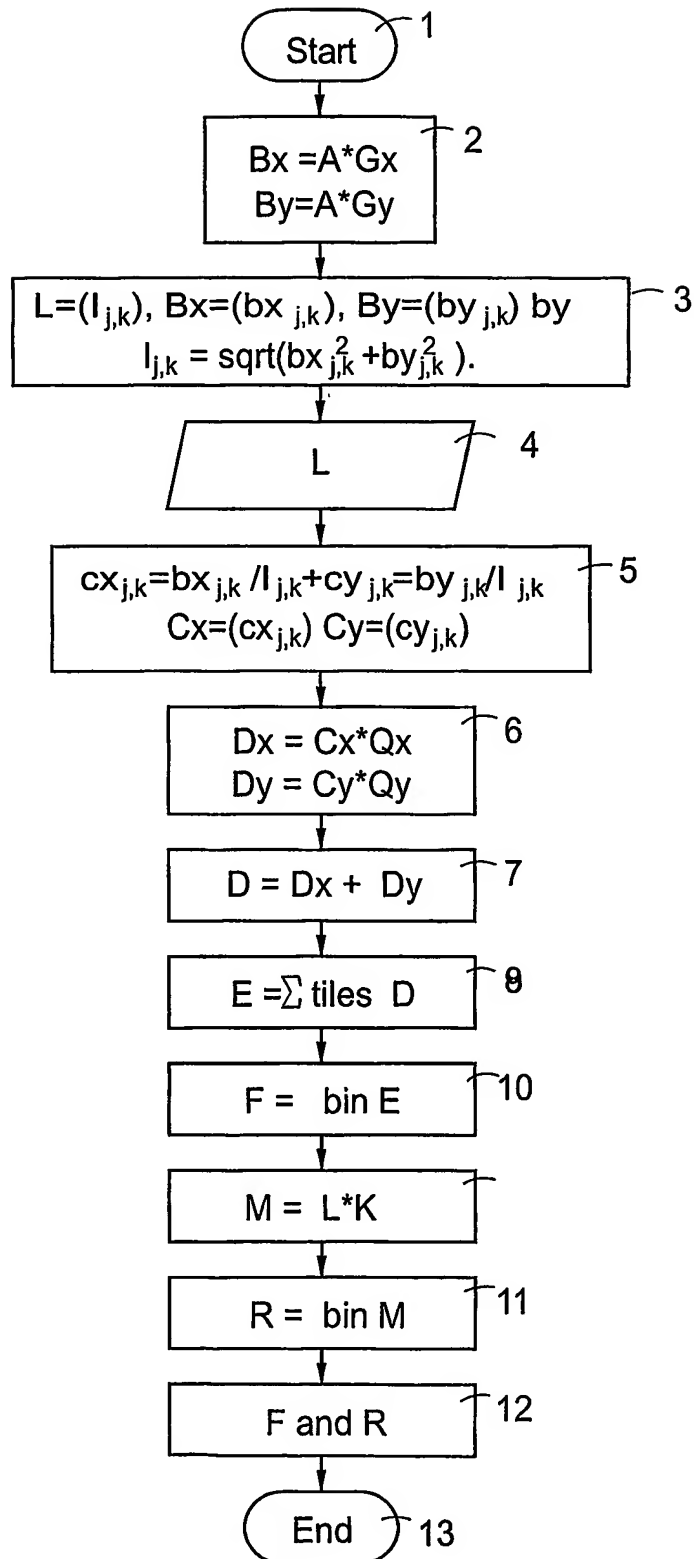


Fig.2

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
11 March 2004 (11.03.2004)

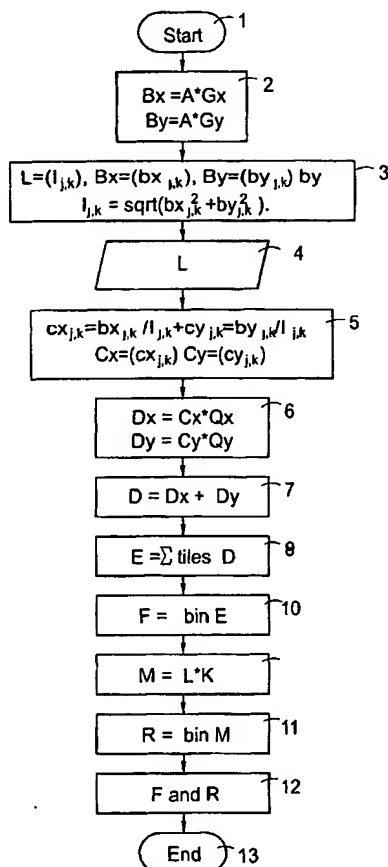
PCT

(10) International Publication Number  
WO 2004/021262 A3

- (51) International Patent Classification<sup>7</sup>: G06K 9/00, 9/46
- (21) International Application Number:  
PCT/IB2003/003695
- (22) International Filing Date: 20 August 2003 (20.08.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
102 39 343.5 28 August 2002 (28.08.2002) DE
- (71) Applicant (for DE only): PHILIPS INTELLECTUAL PROPERTY & STANDARDS GMBH [DE/DE]; Stein-  
damm 94, 20099 Hamburg (DE).
- (71) Applicant (for all designated States except DE, US):  
KONINKLIJKE PHILIPS ELECTRONICS N.V.  
[NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven  
(NL).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): SCHOLZE, Steffen  
[DE/DE]; c/o Philips Intellectual Property & Standards  
GmbH, Weissshausstr. 2, 52066 Aachen (DE).
- (74) Agent: MEYER, Michael; Philips Intellectual Property &  
Standards GmbH, Weissshausstr. 2, 52066 Aachen (DE).
- (81) Designated States (national): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH,  
GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC,  
LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC,  
SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA,  
UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),  
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),  
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,

[Continued on next page]

(54) Title: METHOD AND APPARATUS OF PROCESSING A SKIN PRINT IMAGE



(57) Abstract: In a method and an arrangement for processing a skin print image, and particularly a fingerprint image, which image exists as a gray-level image, provision is made for the gray-level image to be convolved in the direction of two axes (x, y) by generalized gradient filters (Gx, Gy), for the generalized gradients (Bx, By) obtained in this way to be normalized, for the normalized, generalized gradients (Cx, Cy) each to be convolved with generalized gradient filters (Qx, Qy), and for the sum (D) of the two results (Dx, Dy) of the convolution of the normalized, generalized gradients (Cx, Cy) to be converted to binary form.



ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,  
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,  
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(88) Date of publication of the international search report:  
22 April 2004

**Published:**

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

10/525812

## INTERNATIONAL SEARCH REPORT

Internal Application No

PCT/1B 03/03695

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 G06K9/00 G06K9/46

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G06K G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JAIN A K ET AL: "AN IDENTITY-AUTHENTICATION SYSTEM USING FINGERPRINTS" PROCEEDINGS OF THE IEEE, IEEE. NEW YORK, US, vol. 85, no. 9, 1 September 1997 (1997-09-01), pages 1365-1388, XP000738563 ISSN: 0018-9219 page 1373, right-hand column, paragraph 5 -page 1376, left-hand column, paragraph 1 --- -/--	1-6

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*Z\* document member of the same patent family

Date of the actual completion of the international search

9 February 2004

Date of mailing of the international search report

24/02/2004

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Müller, M

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/IB 03/03695

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SIMON-ZORITA D. ET AL.: "An improved image enhancement scheme for fingerprint minutiae extraction in biometric identification" 3RD. INT. CONF. ON AUDIO- AND VIDEO-BASED PERSON AUTHENTICATION, 6 - 8 June 2001, pages 217-222, XP002269478 Halmstad, Sweden page 2 -page 3	1-6
A	IVERSON L A ET AL: "LOGICAL/LINEAR OPERATORS FOR IMAGE CURVES" IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, IEEE INC. NEW YORK, US, vol. 17, no. 10, 1 October 1995 (1995-10-01), pages 982-996, XP000532203 ISSN: 0162-8828 abstract; figures 5,19 page 982, left-hand column, paragraph 1 -right-hand column, paragraph 1	1,2,4,5
A	DERICHE R: "USING CANNY'S CRITERIA TO DERIVE A RECURSIVELY IMPLEMENTED OPTIMAL EDGE DETECTOR" INTERNATIONAL JOURNAL OF COMPUTER VISION, DORDRECHT, NL, 1987, pages 167-187, XP000579415 abstract; figures 1,2 page 169, right-hand column, line 16 - line 20 page 178, left-hand column, paragraph 2 -page 179, left-hand column, paragraph 2	1,2,4,5
A	US 5 659 626 A (ORT JAMES R ET AL) 19 August 1997 (1997-08-19) column 19, line 60 -column 20, line 8; claim 6	2,5

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/IB 03/03695

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5659626	A	19-08-1997	US	5926555 A	20-07-1999
			US	5799098 A	25-08-1998
<hr/>					